EDITORIAL RESEARCH REPORTS

Vol. I
1957

ATOMIC POWER RACE

by

William A. Korns

No. 8
Feb. 27

Editorial Research Reports
1156 Nineteenth Street, N.W.
Washington

ATOMIC POWER RACE

CHEAP NUCLEAR POWER is the goal of an international technological race of increasing scope and intensity. Major development programs are being pressed in the United States, Great Britain, and Soviet Russia. Other industrial nations, faced with growing energy needs, are exploring the possibilities of nuclear power. Spirited commercial competition for reactor and nuclear fuel markets is expected to grow as technical and cost problems are brought nearer to solution. Gains in international prestige and political influence are foreseen for the nation which emerges as the leader in practical application of atom-generated power for peaceful purposes.

These circumstances have prompted members of Congress and others to question the adequacy of present American policy on civilian applications of nuclear energy. Hearings now in progress before the Joint Atomic Energy Committee of the House and Senate point up the fact that, although American scientific and technological effort is being exerted on a wide front, actual construction of full-scale nuclear power plants is farther advanced in Great Britain than in the United States. Fear that the Soviet Union may be moving even more rapidly has led some persons to urge that the government take forceful measures to bring large-scale power reactors into operation at the earliest possible date.

Status of United States Atom Power Projects

Experimental work on power reactors for civilian and military uses has been under way in the United States since 1947, shortly after the Atomic Energy Commission was given responsibility for the country's atomic energy program. In 1951, an experimental breeder reactor at Arco, Idaho, produced useful electric power for the first time. In 1955, the United States Navy launched the first atom-powered submarine, the *Nautilus*, which has logged more than 60,000 miles without refueling.

On Feb. 9, 1957, an experimental boiling water reactor, with an electrical output of 5,000 kilowatts, was put in operation at A.E.C.'s Argonne National Laboratory near Chicago. As yet, however, no full-scale nuclear power plant designed for civilian use has been completed. The first such plant in the United States is scheduled for operation later this year. It is the pressurized water reactor now under construction at Shippingport, Pa., near Pittsburgh. The project, authorized in 1953 under A.E.C.'s five-year experimental power reactor program, is designed to generate 60,000 kw of electricity.[1]

Research and development costs for the Shippingport project total $60 million. The reactor itself will cost $45 million, of which A.E.C. is supplying $40 million. The Duquesne Light Co. is contributing $5 million for the reactor and is building the generating portion of the plant at a cost of $10 million. A.E.C. will own the reactor, but Duquesne will operate the completed plant, paying 8 mills per kilowatt hour to A.E.C. for steam generated by the reactor.

Several other experimental reactors, based on a number of different engineering concepts, are being built by A.E.C., but none of these is designed to furnish as much power as will be generated at Shippingport. Since Congress passed the Atomic Energy Act of 1954, ending the government's complete monopoly over development of atomic energy, A.E.C. has limited its efforts in the civilian power reactor field to research and development, leaving to industry the primary responsibility for financing and building full-scale nuclear power plants.[2]

Participation by Industry in Power Program

In January 1955, A.E.C. invited industry to submit proposals for construction of nuclear power plants with private funds. The agency offered to assume part of the research-development costs, to provide technical assistance and information, and to lease nuclear fuels at stipulated prices. Later in 1955, a second round of proposals, this time for somewhat smaller plants, was invited. A third round was invited in January 1957.

[1] An improved reactor core, to be installed at a later stage, is expected to raise the plant's output to 100,000 kw.

[2] See "Atomic Energy for Industry," *E.R.R.*, Vol. I 1955, pp. 219-236.

Seven of the proposals submitted by industry in 1955 and 1956 were accepted as a basis for negotiation. But only one contract has been signed to date—with Yankee Atomic Electric Co. of Boston, representing a group of New England utilities. Yankee Atomic plans to complete a 134,000-kw pressurized water reactor at Rowe, Mass., by 1960. This contract has been criticized by Comptroller General Joseph Campbell, a former member of A.E.C., as having been signed "without adequate assurances that the government will receive benefits" commensurate with its expenditure.

A temporary construction permit has been awarded the Power Reactor Development Co. of Detroit, which plans a 100,000-kw fast-breeder reactor—one that will produce more fuel than it consumes—at Lagoona Beach, Mich., for completion three years hence. The other five proposals received by A.E.C. in 1955-56 are in various stages of negotiation and planning.[3]

In addition to these projects, all of which involve some government funds, several industrial groups have announced plans to build full-scale nuclear power plants without direct financial assistance from A.E.C. Two of these projects are well advanced—a 250,000-kw pressurized water reactor being built for Consolidated Edison Co. at Indian Point, N. Y., and a 180,000-kw boiling water reactor for Commonwealth Edison Co. at Dresden, Ill. Both plants are scheduled for operation in 1960. A total of some 70 electric utility and other private companies are now engaged in planning or constructing nuclear power stations.

Chairman Lewis L. Strauss of A.E.C. has stated that "there are plans in various states of discussion or negotiation for at least 18 civilian nuclear power plants in this country to come into operation by 1962." These projects, which include A.E.C.'s experimental reactors, will represent "an investment of well over $650 million, with a large proportion of that sum to be supplied by industry itself."[4]

---

[3] They are: Consumers Public Power District, 75,000-kw sodium graphite reactor at Beatrice, Neb.; Rural Cooperative Power Assn., 22,000-kw boiling water reactor at Elk River, Minn.; Wolverine Electric Cooperative, 10,000-kw aqueous homogeneous reactor at Hersey, Mich.; Chugach Electric Assn. and Nuclear Development Corp., 10,000-kw sodium-heavy water reactor at Anchorage, Alaska; and City of Piqua, Ohio, 12,500-kw organic moderated reactor.

[4] Speech by Strauss before the American Nuclear Society, Dec. 11, 1956. An additional project, for a 60,000-kw plant at a site to be selected, was announced Feb. 8 by a group of midwestern utility companies.

Crash Public Program vs. Partnership Plan

NONE of the nuclear power reactors now under construction in the United States is expected to turn out electricity at costs competitive with those of plants using conventional fuels. The true cost of the first power to be generated by the 60,000-kw plant at Shippingport, when put in operation later this year, has been estimated by A.E.C. at 52 mills per kilowatt-hour. This compares with an average charge to A.E.C. of slightly more than 4 mills for electricity consumed at its major production facilities.[5]

The present installed capacity of American electric utilities is 120,000,000 kw. This is expected to grow rapidly in coming years to meet projected increases in demand for power. The extent to which nuclear plants will contribute to the enlargement of capacity hinges almost entirely on possibilities of a sharp reduction in nuclear power costs. The nation's abundant reserves of coal and oil are expected to keep costs of power production from conventional facilities at low levels for an indefinite period.

Proposals for Government Plant Construction

Significant progress toward cost reduction is counted upon by A.E.C. from its research and development activities. At the same time, it is generally recognized that full-scale power reactors must be built and operated in order to achieve measurable economies. Yet so long as conventional plants can be built and operated at a fraction of the cost of nuclear plants, the normal incentives to private investment will remain weak in the United States.

These are among the factors which led Sen. Albert Gore (D-Tenn.), a member of the Joint Atomic Energy Committee, to propose last year a $400 million government-financed "crash" development program. Gore introduced a bill directing A.E.C. to build six full-scale nuclear power plants, each to be of different design and each located in a different part of the country. A.E.C. Commissioner Thomas E. Murray supported the bill, arguing that "the government has prematurely abdicated to private industry the

[5] A.E.C.'s financial report for fiscal 1956 said the agency had consumed in that year "approximately one-tenth of the electric power produced by all the electric utility companies in the United States."

primary responsibility for building large power reactors." But he was a one-man minority on the Commission; the other four members opposed government construction.[6]

Spokesmen for industry viewed Gore's measure as another attempt to put the federal government into the power business. The A.E.C. majority objected that the Commission "would find itself caught in the crossfire of the public versus private power controversy" if the bill should become law. The measure was then modified to provide for construction of an undesignated number of plants by A.E.C. at its own production facilities. A.E.C. was to consume all the electricity generated; none would be offered for sale.[7]

Gore told the Senate last July 12 that the United States, as the only nation which had "used the atom for destruction," had a moral responsibility to lead in the peacetime development of atomic energy. He said private companies could not be expected to assume the risks of investing "$50 million of their money in an atomic power reactor which may become obsolete before it is completed."

Sen. Bourke B. Hickenlooper (R-Iowa), another member of the Joint Atomic Energy Committee, said the changes in the Gore bill had helped to overcome the objections of those who opposed public power development, but added that, if the bill were enacted, it would be "only a step toward nudging the Atomic Energy Commission into the business of producing commercial power."

The Senate passed the bill, 49-40,[8] but the House later voted, 203-191, to recommit a companion measure offered by Rep. Chet Holifield (D-Calif.). Gore and Holifield reintroduced their bills, Jan. 7, 1957, and Democrats are prepared to press for their enactment during the present session of Congress.

Moves to Speed Reactor Building by Industry

In opposing the Gore bill in 1956, A.E.C. denied that the United States was falling behind other nations in the effort to develop cheap nuclear power. On the contrary, the

---

[6] Chairman Strauss, Willard F. Libby, Harold S. Vance, and John von Neumann. Dr. von Neumann died on Feb. 8, 1957, after a long illness.

[7] A.E.C. produces plutonium at Savannah River, S. C., and Hanford, Wash., and U-235 at Oak Ridge, Tenn., Paducah, Ky., and Portsmouth, Ohio.

[8] Three Republicans—Thomas H. Kuchel (Calif.), William Langer (N.D.), and Alexander Wiley (Wis.)—joined 46 Democrats to put the bill through the Senate. All opposing votes were cast by Republicans.

Commission said, its policy, both with respect to domestic development and cooperation with other nations, assured continuing American leadership. Some specific points made by the Commission[9] were the following:

> The goal of United States policy should be the eventual development of economic nuclear electric power and not an immediate kilowatt race with other nations . . .
>
> An aggressive and continuing reactor research and development program is the only basis on which we can establish and maintain world leadership in the development of nuclear power . . .
>
> To prevail in a nuclear kilowatt race might, in the short run, appear to be an accomplishment, but we fear that it would not only be unduly costly in terms of the benefits to be gained, but that it would divert effort and scarce technical manpower from the real goal and consequently delay its achievement . . .
>
> The prototype stage in reactor development is largely concerned with establishing and reducing construction and operating costs . . . We believe it to be of the greatest importance that the maximum economic incentives to cost reduction be preserved at this stage. This, in our opinion, can best be accomplished by industry taking financial and technical responsibility . . .
>
> In our opinion, American industry is responding to this challenge in a very encouraging manner.

Some change in the generally confident attitude displayed last year was reflected in action taken by the Commission shortly after the opening of the 1957 session of Congress. On Jan. 7 a third invitation was extended to industry to submit proposals for building nuclear power plants "as soon as possible." A.E.C.'s only stipulation was that the plants be completed by June 30, 1962. The announcement added: "If industry does not submit acceptable proposals for reactor plants of the types considered ready for full-scale construction, the Commission will request additional funds to initiate such projects under complete federal financing."

A.E.C. offered to waive charges for the use of nuclear materials for five years, to perform work in its laboratories at no cost to industry, and to extend research and development assistance to the point of covering "reactor operation, in recognition of the exigencies related to the experimental nature of the project." However, no A.E.C. funds would be made available for construction of the plants themselves.

The failure to include direct construction subsidies, along with pre-construction and operating assistance, was at-

[9] In a communication to the Joint Atomic Energy Committee, May 18, 1956.

tacked by the American Public Power Association, Feb. 21, as an attempted "freeze-out" of publicly-owned utility systems and electric cooperatives. Samuel B. Morris, representing the association before the Joint Atomic Energy Committee, testified that the terms of A.E.C.'s third-round invitation "not only fail to encourage participation by all segments of the utility industry but actually encourage participation by large public utility combinations exclusively." Elmer L. Lindseth, representing the Edison Electric Institute, took a more favorable view. He told the committee that "substantial progress" had been made in 1956 and that the new A.E.C. proposals would "hasten the day" when nuclear power could be produced on an economic basis.

An official decision to accelerate the power program is reflected in the President's budget estimates for fiscal 1958, as well as in the A.E.C.'s third-round invitation to private industry. Total A.E.C. program costs of $2.2 billion are 24 per cent above 1957's estimated outlays. A proportional increase is projected for reactor development as a whole, but a 60 per cent increase is proposed in funds for civilian power reactors.

PROJECTED A.E.C. EXPENDITURES ON REACTOR DEVELOPMENT

	Fiscal 1956 (actual)	Fiscal 1957 (estimate)	Fiscal 1958 (estimate)
Civilian power reactors	$ 42,267,127	$ 59,600,000	$ 95,000,000
Commercial ship reactors	57,945	3,300,000	3,300,000
Army package power reactors	924,763	3,300,000	5,600,000
Naval propulsion reactors	40,821,589	70,750,000	84,000,000
Aircraft propulsion reactors	49,604,202	89,550,000	91,000,000
Advanced development, etc.	37,554,317	55,213,000	70,300,000
Total reactor development	171,229,943	281,713,000	349,200,000

In addition to the estimates for fiscal 1958, now awaiting action by Congress, A.E.C. plans to ask a supplemental appropriation of $120 million for construction, of which $43 million is for "facilities connected with the development of civilian power reactors."

SAFETY PROBLEMS; INACTION ON INSURANCE LEGISLATION

Radioactivity generated by nuclear fission is an inherent danger in the operation of any reactor. Elaborate and rigid safety standards are prescribed by A.E.C. for handling radioactive materials and design, construction and opera-

tion of reactors. Much of the presently high costs of nuclear power can be traced to such special requirements as blast-proof shields for reactors and other costly safeguards. These precautions have given A.E.C. an excellent safety record.

Over ten years, "99.4 per cent of nearly 200,000 workers of the Commission's 32 principal contractors have averaged an exposure of less than one-third the amount of radiation allowed by strict safety standards." There remains, nonetheless, the distinct although remote possibility of a major disaster, for "any fracture of a reactor structure could be expected to release considerable quantities of highly poisonous radioactive material." [10]

According to A.E.C. Commissioner Willard F. Libby, a runaway 100,000-kw reactor might cause property damage running to $200 million, kill up to 50 persons, and expose 500 others to dangerous levels of radiation. Damage claims resulting from such a catastrophe could reach astronomical proportions. A poll early this year of member organizations of Atomic Industrial Forum, Inc., showed that the difficulty of obtaining adequate insurance coverage at moderate cost was considered one of the main obstacles to more rapid development of nuclear power.

The Nuclear Energy Liability Insurance Association, representing 134 capital stock casualty insurance companies, announced Jan. 31 that it would offer public liability coverage up to $50 million per reactor. A pool of mutual insurance companies is offering up to $15 million in coverage. Industry wants the federal government to assume liability for damages above these amounts.

Last year the Joint Atomic Energy Committee approved a bill to authorize government indemnification of A.E.C. licensees up to a maximum of $500 million. Democrats blocked action on this measure, reportedly in retaliation for defeat of the Gore-Holifield proposal in the House.

Another threat to progress in the nuclear power field is posed by the efforts of three A.F.L.-C.I.O. unions to halt construction by the Power Reactor Development Co. of the fast-breeder reactor near Detroit for which a temporary permit has been granted. The A.E.C. had been told by an advisory committee that not enough was known about

[10] A.E.C., *Twenty-first Semiannual Report*, January 1957, p. 111.

safety of the fast-breeder type of reactor and the unions maintain that location of the plant in a heavily populated area involves unjustifiable hazards.

International Nuclear Power Developments

DIFFICULT TECHNOLOGICAL PROBLEMS are faced by foreign nations, as well as by the United States, in trying to develop cheap nuclear power. Unlike the United States, however, several countries—notably the industrial nations of Western Europe—have strong economic incentives to make a maximum development effort. These countries already depend on imported fuels to fill a large proportion of their energy needs. As these needs increase, so will the cost of fuels from overseas.

Great Britain estimates, for example, that rising industrial production will require a 40 per cent increase in energy supplies over the next 15 years. British coal production, hampered by a manpower shortage, is expected to rise by only 11 per cent during that period. Increased imports of oil to close the gap would put a severe strain on Britain's balance of payments.

On the continent, the six nations in the European Coal and Steel Community now import the equivalent (in coal and oil) of 100 million tons of coal a year, which supplies 25 per cent of their energy requirements. To keep pace with rising needs, imports would have to go up to 200 million tons by 1965 and to 300 million tons by 1975.

The cost of energy in Western Europe already is appreciably higher, on the average, than in the United States. The continent has no substantial oil deposits, and its coal reserves, while still large, are becoming more costly to exploit. Equally important, Western Europe's heavy dependence on imported fuels makes it vulnerable to economic strangulation. The closing of the Suez Canal last autumn, which immediately cut the flow of Mideast oil to Europe, illustrated the critical nature of Europe's energy problem.[11]

[11] See "Suez Dispute and Strategic Waterways," *E.R.R.*, Vol. II 1956, pp. 651-668.

Similar incentives for rapid development of nuclear power are present in Japan, where power now costs about 20 mills per kilowatt-hour. Soviet Russia, while not dependent upon fuel imports, is believed to have overriding political reasons for promoting large-scale atomic projects. Less developed countries hope that the advent of cheap nuclear power will speed their industrialization.

Pace of British and Soviet Reactor Programs

The United States, Great Britain, and Soviet Russia are the only nations known to have produced nuclear weapons. All three thus possess the facilities to turn out nuclear fuels, as well as the advanced technology needed to support major nuclear power programs. British and Soviet capabilities are considered on a par with those of the United States.

In February 1955, the British government announced plans to build a dozen nuclear power plants with a total generating capacity of close to 2 million kw during the ensuing decade. Recently this goal was raised to 4 million kw. The first plant to be completed, at Calder Hall, went into operation in October 1956, with a gross output of 90,000 kw.

The Calder Hall reactor is a gas-cooled, graphite-moderated system in which natural uranium is used as fuel. It is a dual-purpose reactor, in that it produces plutonium as well as power. This system, which will be used in most of the other reactors as now planned, was chosen because of (1) the equally pressing demands for power and for plutonium for use in the British weapons program, and (2) the fact that natural uranium was in greater supply than enriched uranium.[12]

According to Sir Edwin Plowden, chairman of the United Kingdom Atomic Energy Authority, the Calder Hall reactor was not designed "in the most economic way for the production of electricity." In a panel discussion, Sept. 27, 1956, he said the capital costs of Britain's first reactors are expected to be about $420 per kilowatt, compared with $154 for conventional power plants. Fuel costs, however, are expected to be lower. They will be still lower when a method is developed to recycle the plutonium produced

[12] Natural uranium contains only one part in 144 of the fissionable isotope U-235. Most power reactor concepts developed in the United States are based on use of enriched uranium—natural uranium to which varying amounts of U-235 are added. Separation of U-235 in a gaseous diffusion plant is a costly process.

within the reactor. British experts are confident that they will be able to build a competitive nuclear power plant within ten years.

Experimental work on a number of other reactor concepts is being pressed. A full-scale fast-breeder reactor is under construction at Dounreay in the north of Scotland. Industry is participating in the British program, as in the American program, but power in Britain is produced by the Central Electricity Authority, a government monopoly, which together with the Atomic Energy Authority is supplying the funds for all the power reactors now planned.

The extent of Soviet accomplishment in the nuclear power field is not publicly known. In January 1955, the Kremlin announced that a 5,000-kw plant had been in operation since mid-1954. A detailed description of the plant was given at the Geneva conference on peaceful uses of atomic energy held in August 1955.

The Soviets revealed in January 1956 that their sixth 5-year plan called for construction of nuclear power plants with an installed capacity of 2.4 million to 2.5 million kw. And a Soviet official announced in May that five plants, each of 400,000 to 600,000-kw capacity, would be built by 1960 in Moscow, Leningrad, and the Urals. He said also that a nuclear-powered icebreaker was under construction. Russian reactor designs are believed to call for use as fuel of both natural and enriched uranium. The Soviet budget and economic plan for 1957, made public on Feb. 5, indicated that some of the production goals of the 5-year plan had been revised downward, but no change in nuclear power goals was disclosed.

Supranational Euratom Project for West Europe

Next to the Big Three, France has maintained the most active program for development of nuclear power. French plans are based on the dual-purpose reactor used in the British program. Two 35,000-kw plants at Marcoule are scheduled for completion in 1958. France's nationalized power company, Electricité de France, announced plans in 1955 to build five nuclear power stations by 1965.

The French are among the leading proponents of a plan to pool the atomic resources of the six nations of "Little Europe" to relieve the continent's dependence on conven-

tional sources of energy. France's partners in the European Coal and Steel Community—West Germany, Italy, the Netherlands, Belgium, Luxembourg—would join her in a supranational organization, Euratom, which would be given powers similar to those of the U.S. Atomic Energy Commission.

Treaties covering Euratom and a customs union plan are now in the drafting stage; they are expected to be ready for signature in March. Three representatives of the Euratom nations[13] visited Washington in February to discuss possibilities of American cooperation with the proposed organization. They announced a goal of 3 million kw of installed nuclear capacity by 1963, and 15 million kw by 1967. Euratom would arrange the financing, build common facilities, and control the flow of nuclear fuels.[14]

Following discussions with the Euratom representatives, the Department of State and the Atomic Energy Commission stated, Feb. 8, that their 10-year goal of 15 million kw of nuclear power was "feasible." The joint communique said: "The United States Government welcomes the initiative taken in the committee's proposal for a bold and imaginative application of nuclear energy . . . The United States anticipates active association in the achievement of the committee's objective." [15]

United States Cooperation With Foreign Nations

The offer to assist Euratom is another step in the "atoms for peace" program proposed by President Eisenhower in his United Nations address of Dec. 8, 1953. The Atomic Energy Act of 1954 cleared the way for exchanges of information with other nations through agreements for cooperation. Such agreements have been concluded with 39 countries, and involve for the most part various forms of technical assistance, a limited amount of grant aid, and the transfer of small amounts of enriched fuel for use in low-temperature research reactors, a number of which are being built abroad under contract with American firms.

[13] Louis Armand of France, Franz Etzel of Germany, Francesco Giordani of Italy.

[14] A parallel plan for nuclear development is under discussion by the 17 members of the Organization for European Economic Cooperation. That plan does not involve delegation of authority to a supranational body, nor would OEEC build joint facilities. For these reasons, the OEEC proposal has encountered less opposition than Euratom within the countries concerned.

[15] The Soviet government, on July 13, 1956, denounced Euratom and proposed an all-European nuclear power organization as an alternative.

High-temperature power reactors require substantially larger amounts of fuel than low-temperature reactors—whether the fuel be the natural uranium used by the British and French or the enriched uranium used in most American reactors. Washington's intentions with respect to U-235 remained uncertain until the announcement, Feb. 22, 1956, that A.E.C. would make available 40,000 kilograms (about 88,000 pounds) over a period of years. Half of that amount is to be leased to domestic users "principally for power reactors"; the other half will be sold or leased to other countries for power and research reactors. According to the announcement, this amount of U-235 "will support the start of nuclear power programs with a generating capacity of several millions of electrical kilowatts."

The United States has concluded power agreements with eight countries, and negotiations with 15 others are under way. Agreements with Switzerland, the Netherlands and Australia call for supply of 1,500 kilograms of U-235 over the next ten years. A.E.C. announced, Nov. 18, 1956, that it would charge about $16 per gram, and that it would pay $12 a gram for plutonium produced in any foreign power reactors using U-235 supplied by the United States.[16] In approving that announcement, President Eisenhower said it was designed "to enable other nations or groups of nations to have firm assurance of the fuel supplies necessary to the continued operation of nuclear power installations, and thus to facilitate arrangements for financing."

The United States had previously taken the lead in setting up an International Atomic Energy Agency. A statute creating the agency was signed by 70 countries on Oct. 26, 1956, at which time the President allotted 5,000 kilograms of U-235 to the agency and promised, in addition, to match the total contributions of other member nations. The Soviet Union on Feb. 12 became the first nation to ratify the statute.[17]

A preparatory commission is drawing up detailed organization plans for IAEA, which is expected to establish its

[16] Prices set by A.E.C. vary according to the degree of enrichment. One kilogram of uranium enriched to 1 per cent of U-235 is priced at $75.75. One kilogram enriched to 20 per cent—the maximum enrichment permitted for foreign power reactors—comes to $3,223.

[17] Ratification by the United States is expected, despite some opposition in the Senate. Sen. Richard Russell (D-Ga.) said Feb. 13: "I greatly fear we will be making a mistake if we deal with Russia in a field where they have already stolen so many secrets from us." Sen. John W. Bricker (R-Ohio) said the document "should be looked at very carefully to see that our national interests are protected."

headquarters in Vienna. It is not yet clear how the agency will operate. It is authorized to provide materials, services, equipment and facilities for developing nuclear power, "with due consideration for the needs of the underdeveloped areas of the world." The statute gives it power to set up and maintain controls over the use of such nuclear materials as it distributes, in order to prevent their diversion for military purposes. But the extent to which the agency will be active in the nuclear power field is not yet known.

Incentives to Leadership in Atomic Power

NUCLEAR POWER PLANTS are clearly more attractive to nations with high power costs than to those with abundant power resources. Economic considerations, however, are not the only ones which bear on the rate of development. Great Britain's decision to proceed with its construction program on the basis of an inefficient reactor was influenced by the need for plutonium for weapons purposes. The Euratom countries are anxious, for political as well as economic reasons, to free themselves of dependence on the oil of the Middle East.

World aspirations for a better life are, in themselves, a powerful spur to rapid progress. According to Henry DeWolf Smyth, a former member of the U.S. Atomic Energy Commission:

> Decisions about the peacetime development of nuclear energy have not, cannot and probably should not be made on the basis of strict economic realism. Paradoxically, it is more realistic to take account of the profound hopes and illusions which surround the peacetime use of nuclear energy. In the mind of the world it is linked with the desire to promote peace, with regret that one of man's greatest discoveries was first used for destruction and with the belief that such a triumph of the human mind must ultimately bring good.[15]

The all-embracing contest between Soviet Communism and the free world offers a strong incentive to both sides to master the technology of nuclear power. Military considerations have led the United States to give priority to the development of propulsion reactors for submarines, sur-

[15] "Nuclear Power and Foreign Policy," *Foreign Affairs*, October, 1956, p. 2.

face vessels and airplanes, without regard to cost. However, the early development of economic nuclear power plants for civilian use is generally considered of prime importance in the great power competition that lies ahead.

In the uncommitted and underdeveloped countries of Asia and Africa hopes for a rising standard of living rest to a large extent on future availability of cheap electric energy. Few of those countries have the industrial capacity to justify construction of large central power stations of any kind. However, they could use power plants in the range of 5,000 to 30,000 kw, and the nation which first develops economic reactors of that size might be expected to win some influence over the political orientation of such countries.

British and American experts are agreed that ten or more years may be needed to develop small power plants for economic operation in underdeveloped areas. There is some fear that, in the meantime, the Soviets may embark on a program of offering to build small nuclear plants in other countries at a loss simply to get a foothold. Concern over that possibility has led to proposals by Sen. Gore and others that the United States government undertake construction of civilian power reactors abroad as well as at home.

Barring a technological breakthrough it appears doubtful that actual construction of nuclear power plants outside the industrial countries will go forward in the early future. The economic feasibility of nuclear power is not the only stumbling block. Few of the underdeveloped countries have the technicians and engineers needed to operate nuclear installations.

The United States, in addition to offering research assistance under agreements for cooperation, is providing a number of foreign nationals with training in reactor technology. In the past two years more than 150 students from 40 countries have attended the International School of Nuclear Science and Engineering at Argonne National Laboratory.

Exploitation of World Fuel-Reactor Markets

Once nuclear power becomes competitive, a world-wide market for power reactors and associated generating equipment will be at hand. Substantial amounts of uranium and

U-235 will be needed, and fabrication of fuel elements, as well as reprocessing of spent fuels, will give rise to further opportunities in the commercial field.

The British, who depend on exports for economic survival, make no secret of their hope to gain a substantial share of the coming market. Prime Minister Harold Macmillan said Jan. 17: "We lead the world in the production of atomic energy for peaceful and industrial purposes, and we are going to stay in front." West Germany, although still on the threshold of nuclear development, is reported to have long-range plans to compete in the export market for power facilities.[19]

Dr. Chauncey Starr, general manager of Atomics International, told the American Management Association Feb. 8 that U.S. sales of equipment for nuclear power plants, both domestic and foreign, might reach $4 billion by 1966. But Gordon Dean, former A.E.C. chairman, said at the same meeting that American industry might be crowded out of the world market unless government controls over the export of reactors were relaxed.

American firms have announced plans to build more than a dozen small research reactors in other countries, under the terms of A.E.C. cooperation agreements. Westinghouse Electric is at work on the first power reactor for export—an 11,500-kw pressurized water plant for Belgium. Half a dozen other power projects are in negotiation.

The first major test of the competitive status of American and British firms in the power reactor field may come later this year. Japan's Atomic Energy Commission announced plans Feb. 2 to buy 20 reactors and set a five-year goal of 3 million kw installed capacity. Survey groups are to be sent to the United States and Great Britain to select the reactors for use in the Japanese program.

Technical Problems; Possibility of Breakthrough

As many as 100 reactor concepts, employing various combinations of fuels, moderators and coolants, may be technically feasible. But "no one can say which of the presently conceived reactor systems will prove ultimately

---

[19] West Germany plans to have three large-scale reactors in operation by 1960. Atomics Minister Siegfried Balke said in the Bundestag, Feb. 22, that Germany had lagged 10 to 15 years behind in development of atomic energy and now must speed up to a pace exceeding that of Great Britain.

to be the 'best' system."[20] The two systems most fully developed to date (the American enriched uranium-pressurized water reactor and the British natural uranium-graphite reactor) may not be the most efficient for large scale generation of electric power. Yet complete development of any alternative system, from scratchpad to prototype, would cost between $50 million and $100 million.

Nations like Japan, which are prepared to make heavy investments in nuclear power in the near future, must give consideration also to the advantages and disadvantages of different atomic fuels. According to A.E.C.'s director of reactor development, W. Kenneth Davis, "the choice between reactors utilizing enriched uranium and those requiring only natural uranium is a marginal one." Natural uranium is, however, in fairly abundant supply. While its production is still under strict government control in all countries, natural uranium is expected before long to be available for purchase in a free market. U-235, on the other hand, is now a monopoly of the Big Three, and there is little prospect that any other nation or group of nations will be able to produce it in commercial quantities in the near future.

While the United States is believed to be well ahead in the atomic arms race, or to have regained the lead if it once was lost, there is no way of knowing which nation at present holds the best position in the race to develop cheap atomic power. A.E.C. Chairman Strauss has said of the American reactor program that "a major break-through, putting us at or near the goal of economic nuclear power, could come with some suddenness." This possibility exists for Great Britain and the Soviet Union, as well as for the United States.[21] The contest is not yet decided; future world leadership in atomic power seems likely to hinge on new discoveries by British, Russian or American scientists.

[20] International Bank for Reconstruction and Development, "Economics of Nuclear Power," (mimeographed), September, 1956.

[21] Radio Moscow reported, Feb. 21, that Soviet scientists had succeeded in transforming hydrogen into helium at normal temperatures. A Paris dispatch by William H. Stoneman to the *Chicago Daily News* said that if this claim was true, Russia had solved the problem of producing fission without uncontrollable temperatures and thus could harness the fission process for peaceful purposes. The dispatch added: "Direct conversion of nuclear energy into electricity, which appears to be involved . . . . would threaten to make all existing and projected nuclear power plants obsolete."